climate parameters based on changes in external factors that can affect the physical climate (ACIA 2005). Climate models use the laws of physics to simulate the main components of the climate system (the atmosphere, ocean, land surface, and sea ice) (DeWeaver 2007), and make projections of future climate scenarios-plausible representations of future climate-that are consistent with assumptions about future emissions of GHGs and other pollutants (these assumptions are called ''emissions scenarios'') and with present understanding of the effects of increased atmospheric concentrations of these components on the climate (ACIA 2005).

Virtually all climate models use emissions scenarios developed as part of the IPCC effort; specifically the IPCC's *Special Report on Emissions Scenarios* (SRES) (IPCC 2000) details a number of plausible future emissions scenarios based on assumptions on how societies, economies, and energy technologies are likely to evolve. The SRES emissions scenarios were built around four narrative storylines that describe the possible evolution of the world in the 21st century (ACIA 2005, p.119). Around these four narrative storylines the SRES constructed six scenario groups and 40 different emissions scenarios. Six scenarios (A1B, A1T, A1FI, A2, B1, and B2) were then chosen as illustrative ''marker'' scenarios. These scenarios have been used to estimate a range of future GHG emissions that affect the climate. The scenarios are described on page 18 of the *AR4 Working Group I: Summary for Policymakers* (IPCC 2007), and in greater detail in the SRES Report (IPCC 2000).

The most commonly-used scenarios for current-generation climate modeling are the B1, A1B, and A2 scenarios. In the B1 scenario, CO_2 concentration is around 549 parts per million (ppm) by 2100; this is often termed a 'low' scenario. In the A1B scenario, CO_2 concentration is around 717 ppm by the end of the century; this is a 'medium' or 'middle-of-the-road' scenario. In the A2 scenario, CO_2 concentration is around 856 ppm at the end of the 21st century; this is considered a 'high' scenario with respect to GHG concentrations. It is important to note that the SRES scenarios include no additional mitigation initiatives, which means that no scenarios are included that explicitly assume the implementation of the United Nations Framework Convention on Climate Change (UNFCC) or the emission targets of the Kyoto Protocol.

Of the various types of climate models, the Atmosphere-Ocean General Circulation Models (AOGCMs, also known as General Circulation Models (GCMs)) are acknowledged as the principal and most rapidly-developing tools for simulating the response of the global climate system to various GHG and aerosol emission scenarios. The climates simulated by these models have been verified against observations in several model intercomparison programs (e.g., Achuta Rao et al. 2004; Randall et al. 2007) and have been found to be generally realistic (DeWeaver 2007). Additional confidence in model simulations comes from experiments with a hierarchy of simpler models, in which the dominant processes represented by climate models (e.g., heat and momentum transport by mid-latitude weather systems) can be isolated and studied (DeWeaver 2007).

For projected changes in climate and Arctic sea ice conditions, our proposed rule (72 FR 1064) relied primarily on results in the IPCC's *Third Assessment Report* (TAR) (IPCC 2001b), the *Arctic Climate Impact Assessment* (ACIA 2005, p. 99), and selected peer-reviewed papers (e.g., Johannessen et al. 2004; Holland et al. 2006, pp. 1–5). The IPCC TAR used results derived from 9-AOGCM ensemble (i.e, averaged results from 9 AOGCMs) and three SRES emissions scenarios (A2, B2, and IS92a). The ACIA (2005, p. 99) used a 5-AOGCM ensemble under two SRES emissions scenarios (A2 and B2); however, the B2 emissions scenario was chosen as the primary scenario for use in ACIA analyses (ACIA 2005). These reports relied on ensembles rather than single models, because ''no one model can be chosen as 'best' and it is important to use results from a range of models'' (IPCC 2001, Chapter 8). The other peer-reviewed papers used in the proposed rule (72 FR 1064) tend to report more-detailed results from a one or two model simulations using one SRES scenario.

After the proposed rule was published (72 FR 1064), the IPCC released its *Fourth Assessment Report* (AR4) (IPCC 2007), a detailed assessment of current and predicted future climates around the globe. Projected changes in climate and Arctic sea ice conditions presented in the IPCC AR4 have been used extensively in this final rule. The IPCC AR4 used results from state-of-the-art climate models that have been substantially improved over the models used in the IPCC TAR and ACIA reports (M. Holland, NCAR, in litt. to the Service, 2007; DeWeaver 2007). In addition, the IPCC AR4 used results from a greater number of models (23) than either the IPCC TAR or ACIA reports. ''This larger number of models running the same experiments allows better quantification of the multi-model signal as well as uncertainty regarding spread across the models, and also points the way to probabilistic estimates of future climate change'' (IPCC 2007, p. 761). Finally, the IPCC AR4 used a greater number of emissions scenarios (4) than either the IPCC TAR or ACIA reports. The emission scenarios considered in the AR4 include A2, A1B, and B1, as well as a ''year 2000 constant concentration'' scenario; this choice was made solely due to the limited computational resources for multi-model simulations using comprehensive AOGCMs, and ''does not imply any preference or qualification of these three scenarios over the others'' (IPCC 2007, p.761). For all of these reasons, there is considerable confidence that the AOGCMs used in the IPCC AR4 provide credible quantitative estimates of future climate change, particularly at continental scales and above (IPCC 2007, p. 591), and we have determined that these results are rightly included in the category of best available scientific information upon which to base a listing decision for the polar bear.

In addition to the IPCC AR4 results, this final rule utilizes results from a large number of peer-reviewed papers (e.g., Parkinson et al. 2006; Zhang and Walsh 2006; Arzel et al. 2006; Stroeve et al. 2007, pp. 1–5; Holland et al. 2006, pp. 1–5; Wang et al. 2007, pp. 1,093–1,107; Overland and Wang 2007a, pp. 1–7; Chapman and Walsh 2007) that provide more detailed information on climate change projections for the Arctic.

Uncertainty in Climate Models

The fundamental physical laws reflected in climate models are well established, and the models are broadly successful in simulating present-day climate and recent climate change (IPCC 2007, cited in DeWeaver 2007). For Arctic sea ice, model simulations unanimously project declines in areal coverage and thickness due to increased GHG concentrations (DeWeaver 2007). They also agree that GHG-induced warming will be largest in the high northern latitudes and that the loss of sea ice will be much larger in summer than in winter (Meehl et al. 2007, cited in DeWeaver 2007). However, despite the qualitative agreement among climate model projections, individual model results for Arctic sea ice decline span a considerable range (DeWeaver 2007). Thus, projections from models are often expressed in terms of the typical